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AUTHOR	Keeling, Charles D.
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ABSTRACT

This booklet is one of a series intended to provide explicit instructions for the collection of oceanographic data and samples at sea. The methods and procedures described have been used by the Scripps Institution of Oceanography and found reliable and up-to-date. Instructions are given for taking air samples on board ship to determine the concentration of atmospheric carbon dioxide. Information covers unpacking and repacking of flasks, storage of flasks, choosing a sampling site, indoor preparation, taking the sample, sampling in cold weather, sampling during rough seas, time of sample, recording the data, and returning the flasks. Illustrations of three flasks and their uses and a sample data sheet are also included. (BL)

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The Scripps Institution of Oceanography

MARINE TECHNICIAN'S HANDBOOK

INSTRUCTIONS FOR TAKING AIR SAMPLES ON BOARD SHIP: CARBON DIOXIDE PROJECT

Charles D. Keeling

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GENERAL INTRODUCTION

This publication is one of a series intended to provide explicit instructions for the collection of oceanographic data and samples at sea. Individual chapters are being issued separately so that they may be made available as they are prepared and may be replaced by updated versions without replacing the entire series. It can, therefore, be considered as an open-ended "marine technician's handbook".

For many years there have been such manuals in existence within various groups at the Scripps Institution of Oceanography for internal use. These manuals are being updated, and new ones are being prepared where no satisfactory ones existed; they will be issued as they are ready.

The instructions on physical, biological, and chemical oceanographic data collection and processing have been prepared by members of the Data Collection and Processing Group (DCPG), part of the Marine Life Research Group of Scripps. They cover procedures used by that group. Other chapters on geological and geophysical techniques are based on the "Marine Technician's Handbook" series originally prepared by Mr. Frederick S. Dixon, and issued by the Oceanic Research Division some years ago. It is expected that chapters on techniques used by other groups within Scripps will be added.

Since the sections will be published individually, there will undoubtedly be some repetition. This should not detract from the overall purpose of the manual, since it is expected that a single section will be the only one needed for a particular operation. We do not wish to suggest that the methods described are the only methods; we have merely attempted to describe the methods and procedures which we use and which we have found to be reliable and up-to-date. As new information becomes available, attempts are made to test techniques, incorporate them into routine procedures, and then revise the chapter concerned.

In the final analysis the reliability and quality of the data obtained is in your hands. It is imperative that meticulous attention be given to details to insure reliability and usefulness in the results you obtain.

While we have attempted to be thorough in descriptions of techniques, this cannot be considered to be a complete "cookbook" for the novice. It is in most cases assumed that the reader has some prior knowledge and training in the field concerned. We hope, however, that these instructions can serve as a training aid for the novice marine technician, a "cookbook" for the scientist who is taking his own observations, and a reference manual for the experienced technician.

Preparation of these chapters over the years has been supported by the University of California and by grants and contracts from the many federal agencies to the Scripps Institution of Oceanography and to the Institute of Marine Resources. Support for preparation of this more complete and revised manual has come from the National Sea Grant Program. This chapter, Instructions for Taking Air Samples on Board Ship: Carbon Dioxide Project, was prepared by Dr. Charles Keeling, Professor of Oceanography.

G. G. Shor, Jr.
Sea Grant Program Manager

Carbon Dioxide Project
October 15, 1971

INSTRUCTIONS FOR TAKING AIR SAMPLES ON BOARD SHIP

CARBON DIOXIDE PROJECT

(Revised July, 1971)

Charles D. Keeling

DESCRIPTION

Air samples are taken to determine the concentration of atmospheric carbon dioxide. They are collected in glass flasks, equipped with greased stopcocks, that have been pumped to a high vacuum before being packed for shipment. The three types of flasks used by Scripps Institution of Oceanography are pictured in Figure 1. Type 1 is not currently in use. Types 2 and 3 are described below.

UNPACKING AND REPACKING FLASKS

In each of the three types the narrow curved glass neck that joins the body of the flask to its stopcock is highly susceptible to breaking. To minimize this danger and its resultant inconvenience, detailed instructions are given for packing and repacking.

Type 2: Cylindrical Flasks in Dozens

These flasks are supplied by fours in wooden boxes which are, in turn, packed in shipping trunks, three boxes to a trunk. The trunk latches are secured with bolts or with baling wire. Remove the wooden boxes from each shipping trunk and carefully inspect for breakage, as discussed below, as soon as possible after they arrive. Unpack and handle flasks with extreme care.

Remove the lid from each box to uncover the flasks enclosed in cardboard sleeves. (See Figure 1. The center flask "Type 2" is pulled partly out of the sleeve to show the stopcock.) NEVER PULL ON THE STOPCOCK to remove the flask from its cardboard sleeve: such action could easily break the fragile glass neck. Instead, push the flask from the bottom. If the flask is too tightly held by the cardboard, cut the tape and partially unroll the sleeve to free the flask so that it can be pushed out easily.

It is not always necessary to remove the entire flask from the cardboard sleeve to inspect for breakage. The most frequent damage is the breaking off of a stopcock at the neck of its flask; the body of a flask, however, is seldom injured in shipping. Since damaged flasks can be repaired, stopcocks found broken off during shipping

should be wrapped separately, secured in their sleeves to prevent additional damage, and repacked. SAVE ALL PACKING MATERIAL and repack the flasks in the same arrangement as received, including any broken ones.

Flasks should be exposed in numerical order. The numbers of the four flasks contained in each box are printed on the box. The boxes are arranged in the trunk from left to right in ascending numerical order.

After all of the samples have been taken, according to instructions given below, and the flasks and wooden boxes have been repacked in their respective trunks, band the trunks or secure them with a rope or baling wire, so that if the latches should be accidentally opened or broken, the trunks will stay closed.

Type 3: Five-liter Flasks in Half Dozens

The five-liter flasks are packed in sixes in wooden trunks. (This type of flask is shown in the foreground of Figure 1.) The packing material consists of styrofoam sheets glued together. Each flask sits in a cylindrical hole in the styrofoam with its stopcock protected by a single piece of hairflex folded and taped. Four loosely-fitting styrofoam blocks or a round styrofoam collar surrounds the neck of the flask to hold it in place in the hole.

A 4-inch thick styrofoam lid fits over the styrofoam insert. On the underside of the lid are six rectangular cavities about 2 inches deep into which fit the hairflex-covered stopcocks. When the styrofoam lid is properly in place, it is flush with the top edges of the packing trunk. To remove or replace it, slide it straight up and down with perhaps some end-to-end motion. Use the indentations provided for grasping the lid.

The flasks should be inspected for breakage upon receipt, following the instructions given in the description of flask type 2 above. It is not necessary to cut the tape on the hairflex covering the stopcocks; simply slide the hairflex off.

Flasks should be exposed in numerical order and are arranged in the trunk as follows: left front, left rear, middle front, middle rear, right front, right rear. The numbers of flasks contained in the trunk are printed on the underside of the lid.

After all of the samples have been taken, according to instructions given below, check that the flasks are packed correctly in the trunks. Band the trunks or secure them with a rope or baling wire. Also secure the trunk latch with baling wire.

STORAGE OF FLASKS

If possible, the flasks should be stored inside the boxes in a room with a temperature between 50° and 75°F. Temperatures from -100°F to 85°F can be tolerated, however. Boxes should never stand more than thirty minutes in the direct sun, nor anywhere that the temperature is above 85°F. Light also affects stopcock grease adversely: except during inspection and sampling, flasks should therefore be stored with the lids on the boxes.

CHOOSING A SAMPLING SITE

Samples are used in determining the carbon dioxide content of the air. Since smoke stacks, people, gasoline engines, birds, other boats, etc., give off carbon dioxide in amounts many times greater than that contained in a pure air sample, all (including the technician's breath) are sources of contamination to the sample. To prevent a useless sample being taken, the sample should be taken facing INTO the wind, preferably near the bow, with the ship moving into the wind. If the direction of the ship cannot be controlled to bring about this condition, take samples at whatever quarter the wind presents itself provided that it has a velocity relative to the ship of at least 5 knots and has been steady for 10 minutes or more. NEVER TAKE SAMPLES WHEN THE RELATIVE WIND IS LESS THAN 5 KNOTS OR IS VARIABLE.

INDOOR PREPARATION

While still within a warm protected part of the ship, prepare for sampling as follows:

(1) Unpack the flasks according to instructions. A trunk of flasks should be exposed in ascending numerical order.

(2) Holding the glass flask against your body, grip the barrel of the stopcock with the left hand and point the stopcock away from you. With the right hand turn the stopcock clockwise 90 degrees (1/4 of a complete revolution). Note how it functions; the

closure is a hole in the stopcock plug which is upward and visible at the one-quarter turn. Before taking the sample outside, figure out how the stopcock will make the other 1/4 turn, since you will be holding your breath during sampling and will have little time.

(3) Locate one of the wooden dowel plugs that have been provided with each shipment of flasks and, after removing the protective cork from the entrance of the ground joint on the sampling flask, place the dowel plug in the neck of the flask and leave it there until sampling time.

TAKING THE SAMPLE

At the sampling site, see that all ship personnel are downwind and at least fifteen feet away except when an assistant is necessary during rough weather. When ready to sample, take a deep breath and exhale until the lungs feel comfortable. DO NOT EXHALE AGAIN until after the sample is taken and the flask is closed. If possible, walk five to ten feet further upwind. Move the dowel plug in and out of the neck 10 times to purge the neck of the flask. (Figure 2 shows this procedure using a 5-liter flask.) Before opening the stopcock, remove the dowel plug and hold the flask well away from the face. (Note Figure 3: the flask is held at arm's length for collecting the sample.) The barrel of the stopcock is held firmly in the left hand while the handle is turned with the right. If the INDOOR PREPARATION procedure was carried out correctly, the stopcock should turn fairly easily. Slowly and firmly turn the stopcock handle, remembering that excessive torque will snap the delicate neck. The colder the weather the greater the care needed for turning the stopcock plug. Grasping the stopcock in the left hand helps to keep it warm while also reducing the strain on the neck as it is turned. (Additional directions for manipulation of the stopcock in cold weather are given below.)

Open the stopcock to collect the sample. After the suction (a hissing sound) has ceased for 15 seconds, close the stopcock to an angle of at least 45 degrees before exhaling. If possible, close the stopcock 45 degrees more while still at the sampling site, carry the flask back into the laboratory and allow it to warm. Once the sample has been collected and the pressure inside the flask is equal to that on the outside, be careful not

to pull the stopcock out of the barrel when turning. Before packing the flask, tape the stopcock shut so that agitation or warming of the flask will not "pop" the stopcock. Several turns of the tape around the stopcock handle and bulb (perpendicular to the neck of the flask) should be sufficient. Replace the cork. The flask is ready to pack.

SAMPLING IN COLD WEATHER

In cold weather it may be necessary to warm the stopcock before sampling to lessen the difficulty in turning it.

When ready to go outside, carefully warm the stopcock over the flame of a gas stove, with the flame of a torch, or with a cigarette lighter. Heat until the stopcock turns freely, then grasp its barrel with your bare left hand. Continue to grasp it while walking to the sample site and until after the sample is taken and the stopcock has been closed at least 45 degrees. If it is too cold to endure bare hands, it may be possible to sample successfully while wearing gloves.

Returning indoors after taking the sample, WARM THE STOPCOCK AGAIN. As soon as it will turn fairly freely, close it to a full 180 degrees (1/2 a complete revolution) and store it.

SAMPLING DURING ROUGH SEAS

Because the sampling sequence requires the use of two hands, rough seas may make it necessary to have an assistant hold on to you and steady you during sampling. He should stand downwind from you; however if the wind is stronger than 15 knots, as it usually is during rough seas, the precautions regarding local contamination can be relaxed somewhat to give you more choice in finding a comfortable place to stand. Any position upwind of the main exhaust stacks will suffice, but avoid sampling in spray.

TIME OF SAMPLE

Unless otherwise instructed, all samples should be taken between 1200 and 1600 local time, and should be taken in duplicate. The procedure is followed completely for the first flask with a second sample being taken in the same manner as soon as possible thereafter. If wind and sea conditions are adverse, sampling can be postponed for one or more days.

RECORDING OF DATA

Record the data on the special data sheets supplied, using one data sheet for each pair of samples unless otherwise instructed. A sample data sheet properly filled in is indicated in Figure 4.

RETURNING THE FLASKS

Repack the flasks and data sheets in the shipment trunks using the original packing material and observing all precautions as given above.

LIST OF FIGURES

Figure 1. Three types of sampling flasks currently in use.

Figure 2. Purging procedure shown using 5-liter flask.

Figure 3. Sampling position with cylindrical flask.

Figure 4. Sample data sheet.

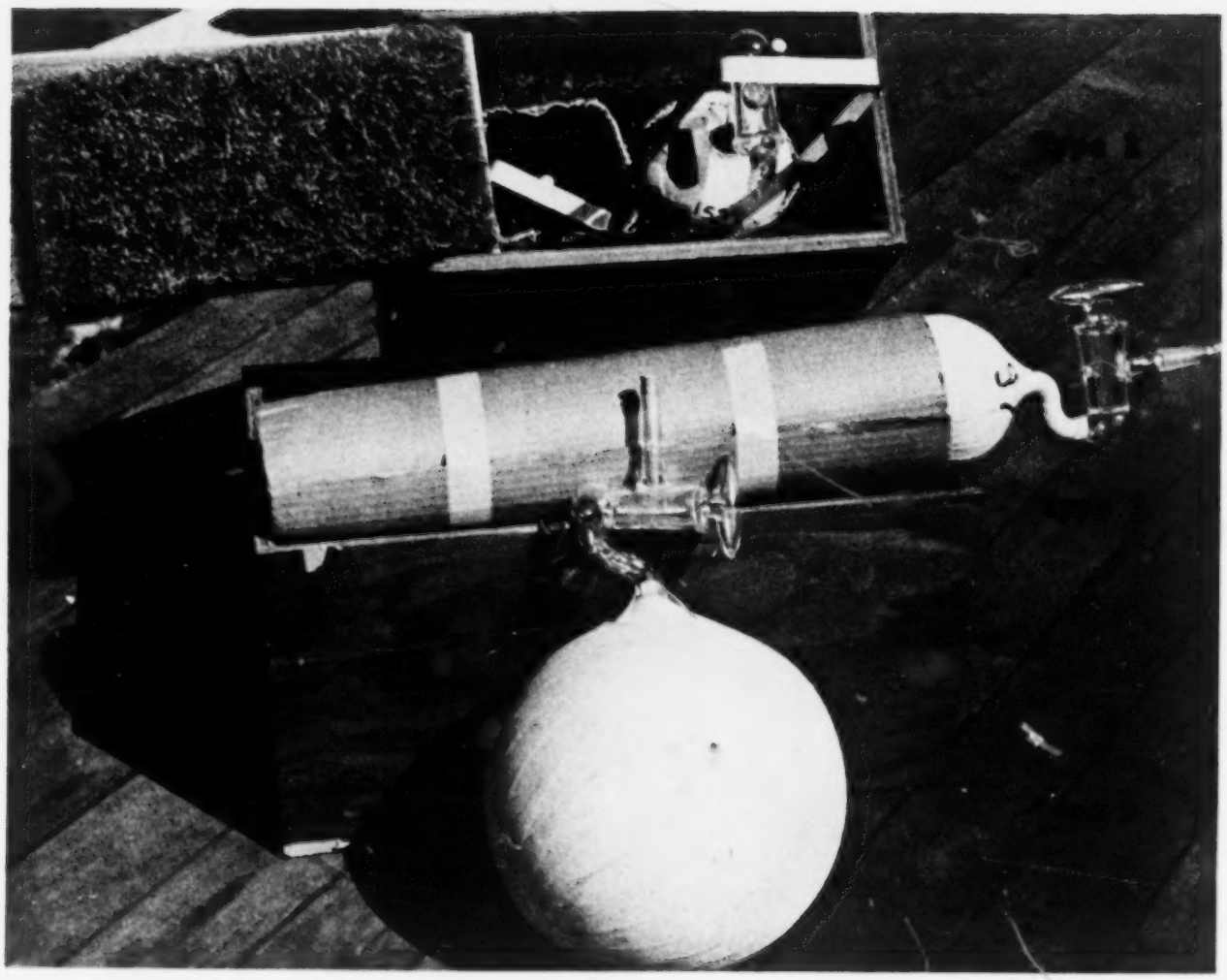

FIGURE 1 - Three types of sampling flasks currently in use.

FIGURE 2 - Purging procedure shown using 5-liter flask.

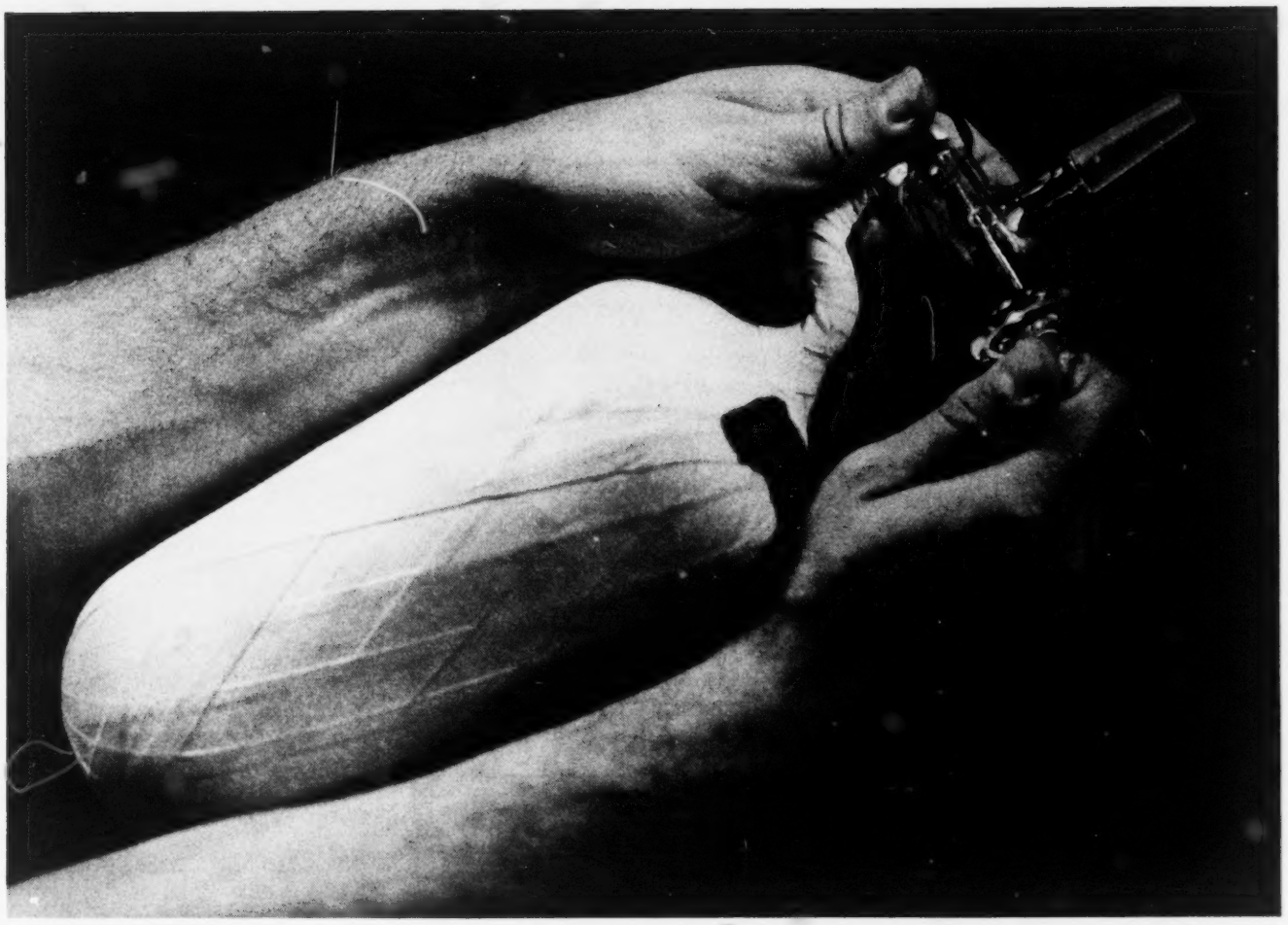

FIGURE 3 - Sampling position with cylindrical flask.

PROJECT CARBON DIOXIDE SHIPBOARD DATA SHEET NO. 26

Observer's name Keith Date Jan 14, 1963

Vessel name ARGO Local Time 1320 (Z)

Cruise name LUSIAD Time Zone + 5

Latitude 2° 30'N Longitude 75° 27'E

Air Temp. (°F) 81.9 Wet Bulb Temp (°F) 79.3

Relative Humidity (%) _____ Surface Water Temp (°F) 23.8

Barometer (inches of mercury) 29.95

Weather overcast Cloud Type Ac Cloud Amount 10/10

Visibility good Sea 1 Sonic Depth (Fathoms) 1876

Ships Head (Deg.) 090

Ships Speed (Knots) 10.4

Relative Wind Dir. (Deg.) 180

Relative Wind Speed (Knots) 12

True Wind Dir. (Deg.) _____

True Wind Speed (Knots) _____

Was observer able to close stopcock immediately after the sample was taken?

yes Did the flask make a hissing sound when opened? yes

Remarks Samples taken on fantail underneath "A" frame

Number of first sampling flask 43 Number of second flask 44

FIGURE 4 - Sample data sheet.